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Figure 1a

Figure 1b

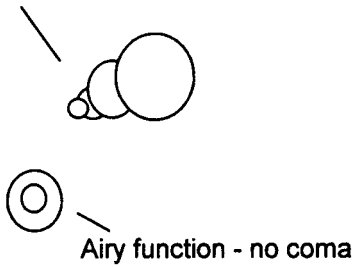


Figure 1d

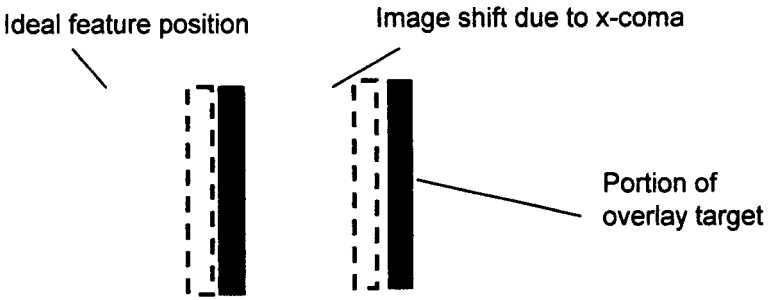


Figure 1c

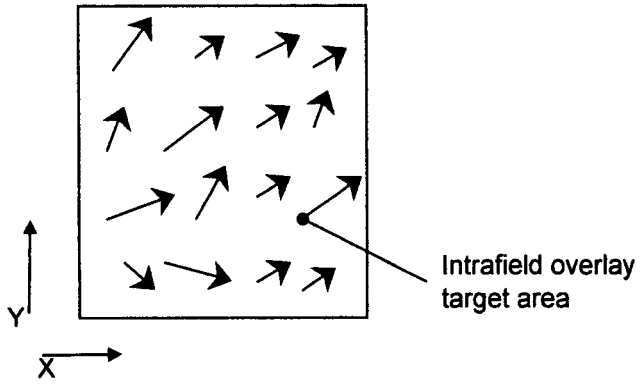
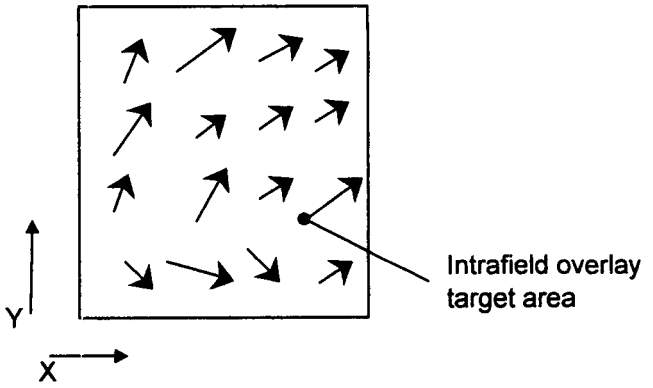


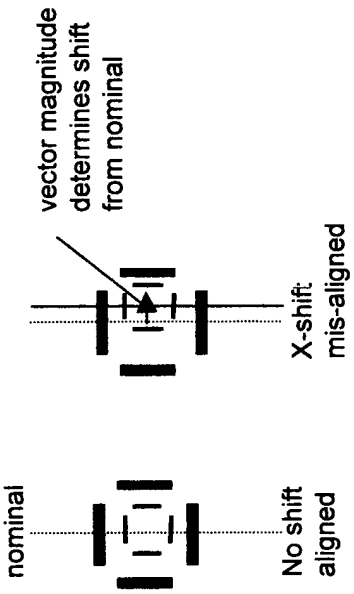
Figure 1e

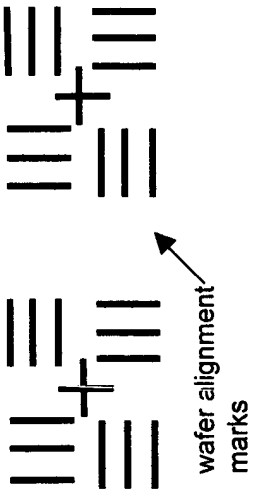


Heller Ehrman White & McAuliffe LLP
Title: "PROCESS FOR DETERMINATION OF OPTIMIZED EXPOSURE CONDITIONS FOR TRANSVERSE DISTORTION MAPPING"
Inventor(s): A. Smith et al.
Application No.: 10/800,110 – Filed: 03/12/2004
Atty Docket No.: 38203-6295
2/23

Figure 2a

Figure 2b





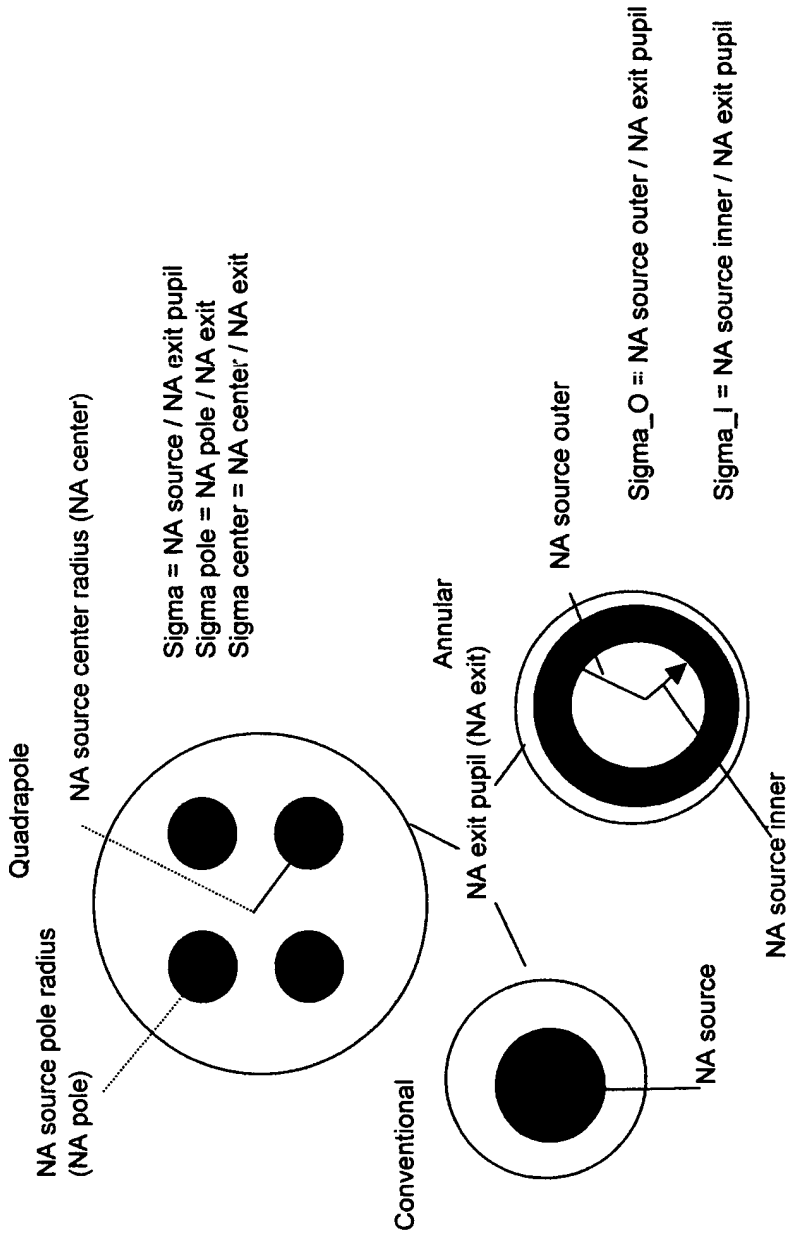

Quadrapole
NA source center radius (NA center)
NA source pole radius (NA pole)
Sigma = NA source / NA exit pupil
Sigma pole = NA pole / NA exit
Sigma center = NA center / NA exit
Annular
NA exit pupil (NA exit)
NA source outer
Sigma_O = NA source outer / NA exit pupil
Sigma_I = NA source inner / NA exit pupil
NA source inner
Conventional
NA source

Figure 3

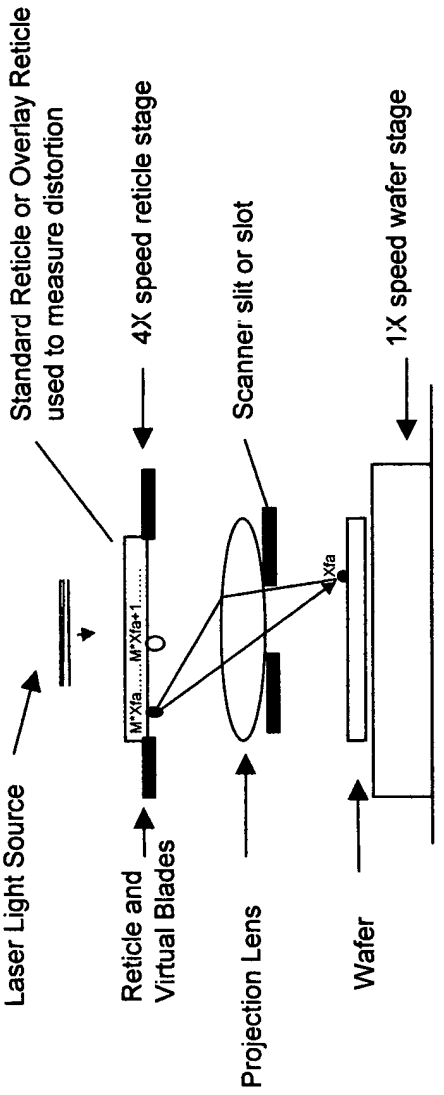

Standard Reticle or Overlay Reticle used to measure distortion
4X speed reticle stage
Scanner slit or slot
1X speed wafer stage
M*Xfa.....M*Xfa+1.....
Xfa
Laser Light Source
Reticle and Virtual Blades
Projection Lens
Wafer

Figure 4a

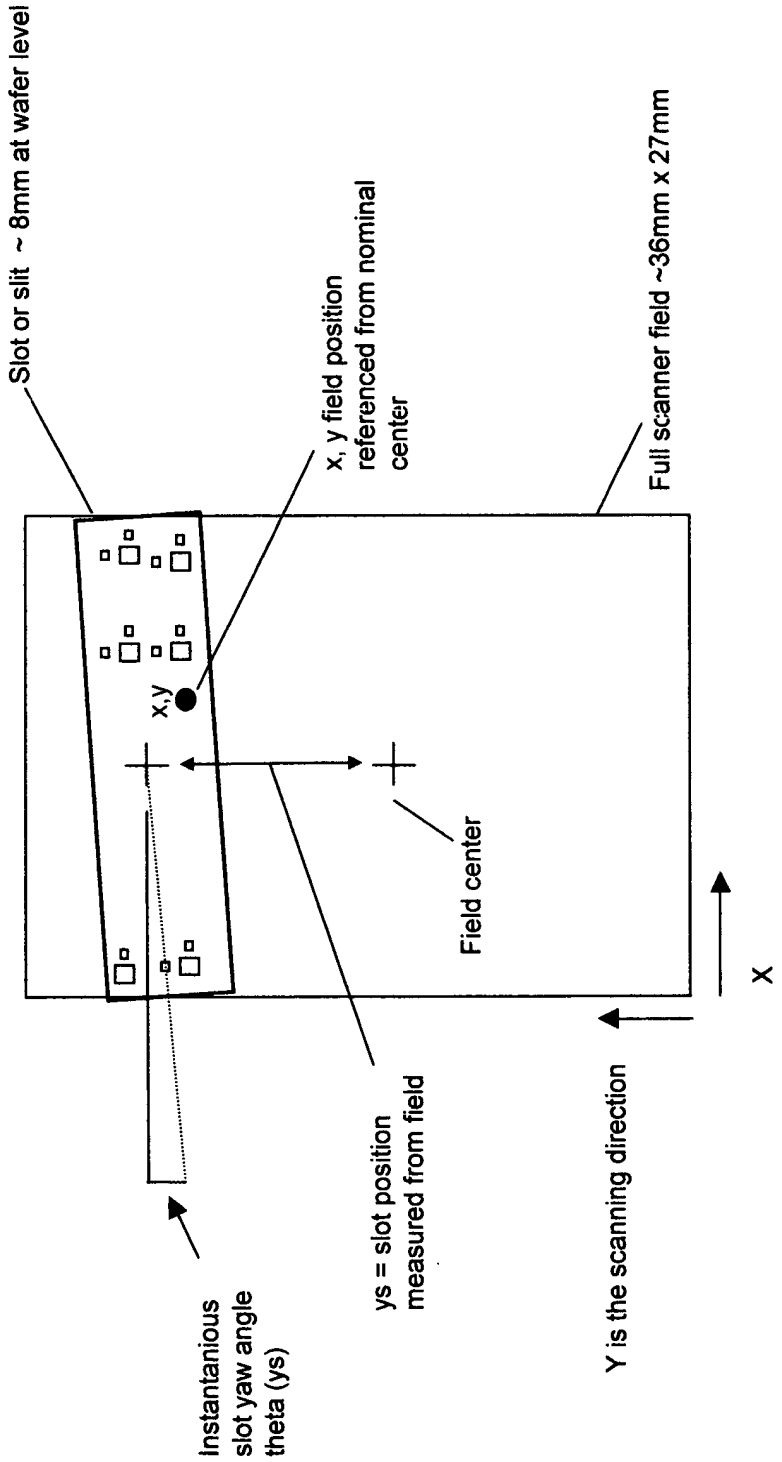
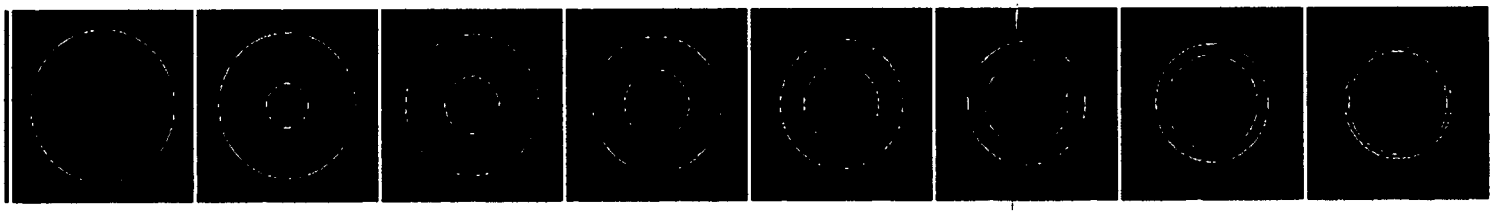

Slot or slit ~ 8mm at wafer level
x, y field position referenced from nominal center
Full scanner field ~36mm x 27mm
x,y
Field center
X
Instantanious slot yaw angle theta (ys)
ys = slot position measured from field
Y is the scanning direction

Figure 4b

1um space/4um pitch
400nm resist Threshold model,
E/Eo = 3, focus =150nm

SOURCE SHAPES IN GENERALLY ACCESSIBLE OR 'PRACTICAL' REGION. PRACTICAL REGION IS SIGMA_O < 0.8 AND 0.25 < EPS < 0.75

NA = 0.60, LAMBDA = 248NM



SIGMA_O	0.836	0.797	0.772	0.746	0.714	0.684	0.653	0.621
SIGMA_I	0	0.239	0.309	0.373	0.428	0.479	0.522	0.559
EPS	0	0.3	0.4	0.5	0.6	0.7	0.8	0.9

EPS = fractional size of hole in source = SIGMA_I / SIGMA_0

Figure 5a

Heller Ehrman White & McAuliffe LLP
Title: "PROCESS FOR DETERMINATION OF OPTIMIZED EXPOSURE CONDITIONS FOR TRANSVERSE DISTORTION MAPPING"
Inventor(s): A. Smith et al.
Application No.: 10/800,110 – Filed: 03/12/2004
Atty Docket No.: 38203-6295
7/23

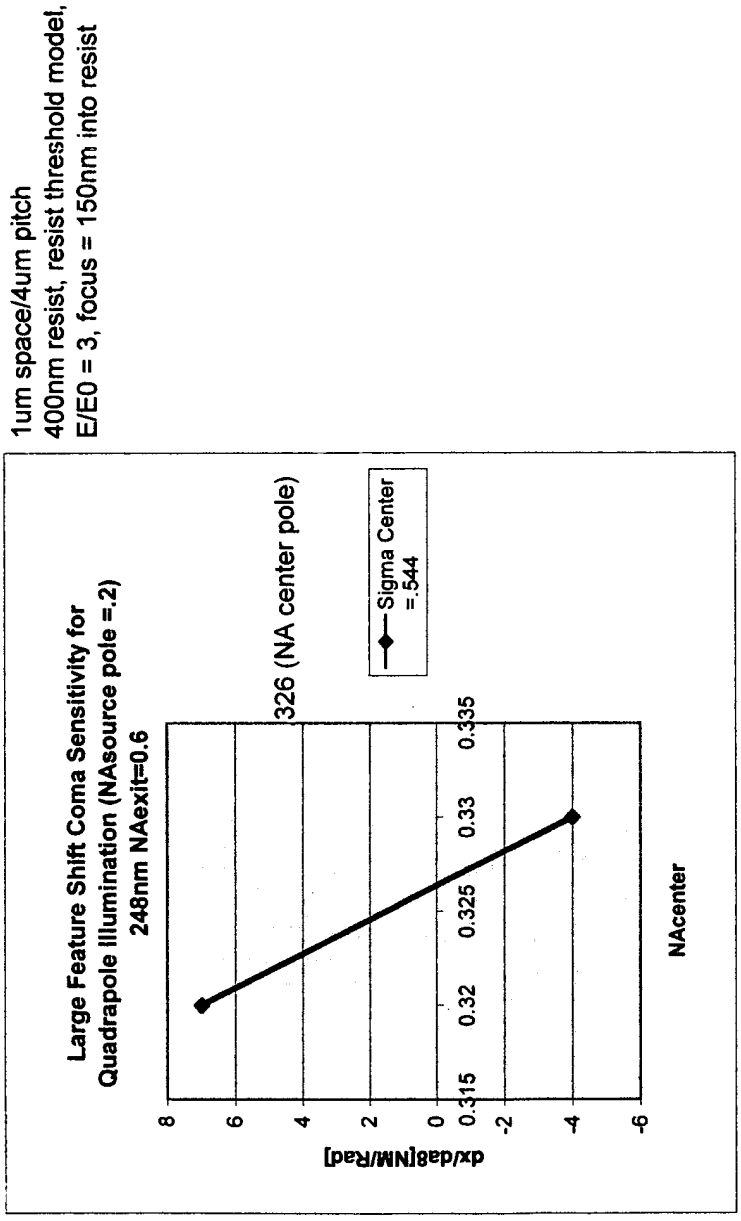

1um space/4um pitch
400nm resist, resist threshold model,
E/E0 = 3, focus = 150nm into resist
Large Feature Shift Coma Sensitivity for
Quadrapole Illumination (NAsource pole =.2)
248nm NAexit=0.6
326 (NA center pole)
Sigma Center
=.544
dx/da8[NM/Rad]
8
6
4
2
0
-2
-4
-6
0.315
0.32
0.325
0.33
0.335
NAcenter

Figure 5b

Figure 6a

Wavelength	NA exit	NA pole	NA center	Sigma Pole	Sigma Center
365nm	0.6	0.2	0.3270	0.3333	0.5450
248nm	0.6	0.2	0.3263	0.3333	0.5438
193nm	0.6	0.2	0.3232	0.3333	0.5387
157nm	0.6	0.2	0.3189	0.3333	0.5315

Figure 6b

Wavelength	NA exit	NA pole	NA center	Sigma Pole	Sigma Center
365nm	0.9	0.2	0.4995	0.2222	0.5550
248nm	0.9	0.2	0.4818	0.2222	0.5353
193nm	0.9	0.2	0.4725	0.2222	0.5250
157nm	0.9	0.2	0.4719	0.2222	0.5243

Heller Ehrman White & McAuliffe LLP
Title: "PROCESS FOR DETERMINATION OF OPTIMIZED EXPOSURE CONDITIONS FOR TRANSVERSE DISTORTION MAPPING"
Inventor(s): A. Smith et al.
Application No.: 10/800,110 – Filed: 03/12/2004
Atty Docket No.: 38203-6295
9/23

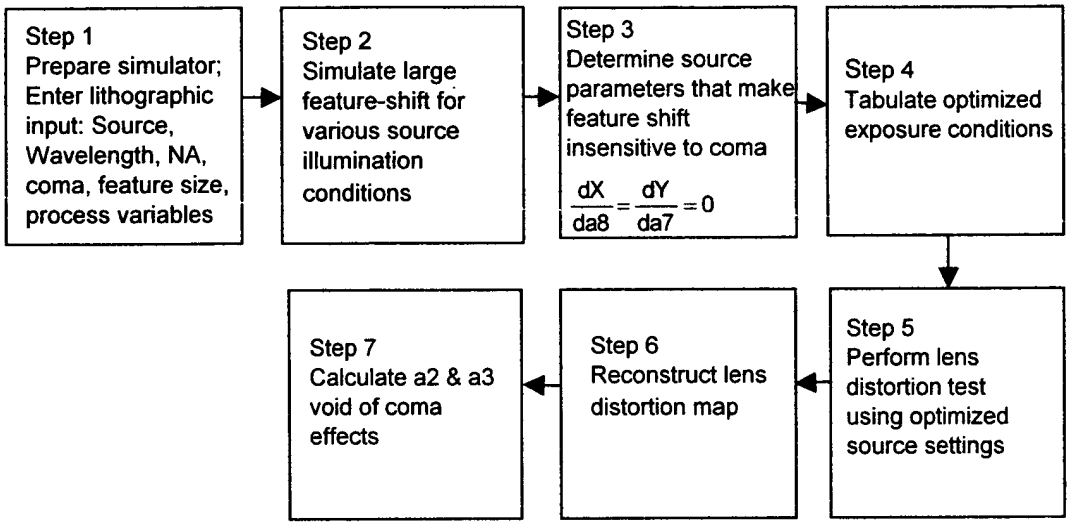

Step 1
Prepare simulator; Enter lithographic input: Source, Wavelength, NA, coma, feature size, process variables
Step 2
Simulate large feature-shift for various source illumination conditions
Step 3
Determine source parameters that make feature shift insensitive to coma
$\frac{dX}{da8} = \frac{dY}{da7} = 0$
Step 4
Tabulate optimized exposure conditions
Step 5
Perform lens distortion test using optimized source settings
Step 6
Reconstruct lens distortion map
Step 7
Calculate a2 & a3 void of coma effects

Figure 7a

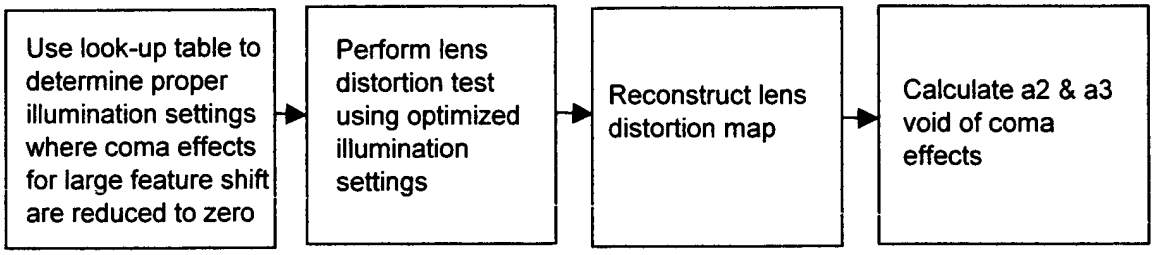

Use look-up table to determine proper illumination settings where coma effects for large feature shift are reduced to zero
Perform lens distortion test using optimized illumination settings
Reconstruct lens distortion map
Calculate a2 & a3 void of coma effects

Figure 7b

1um space/4um pitch
400nm resist, resist threshold model, E/E0 = 3
focus = 150nm

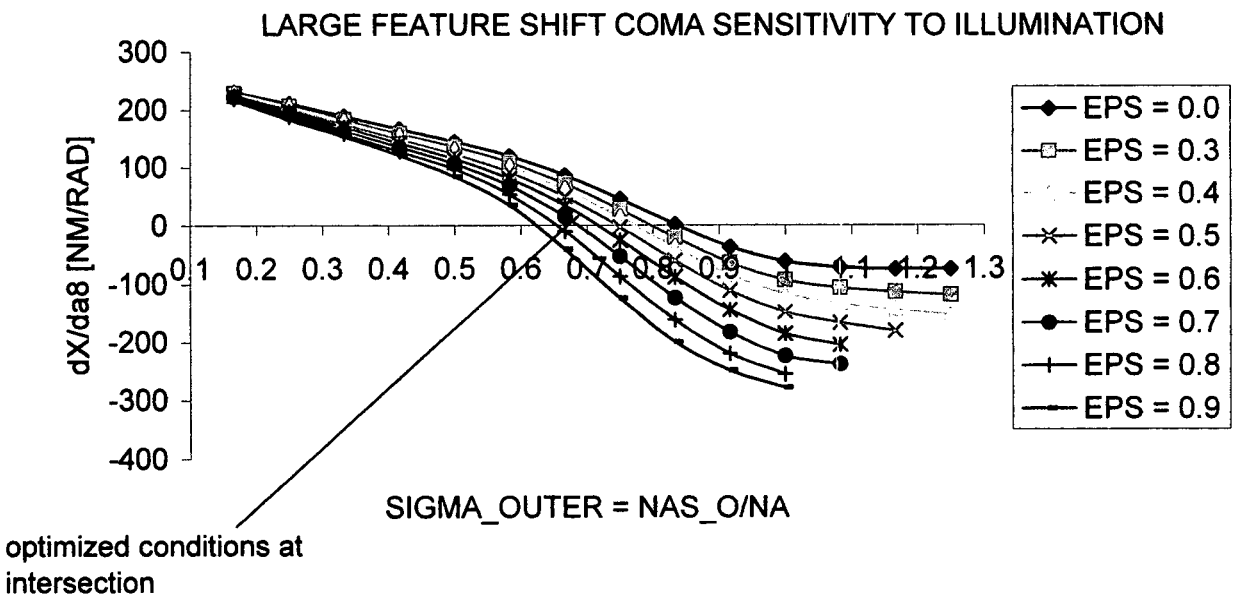


Figure 8a

Heller Ehrman White & McAuliffe LLP
Title: "PROCESS FOR DETERMINATION OF OPTIMIZED EXPOSURE CONDITIONS FOR TRANSVERSE DISTORTION MAPPING"
Inventor(s): A. Smith et al.
Application No.: 10/800,110 – Filed: 03/12/2004
Atty Docket No.: 38203-6295
12/23

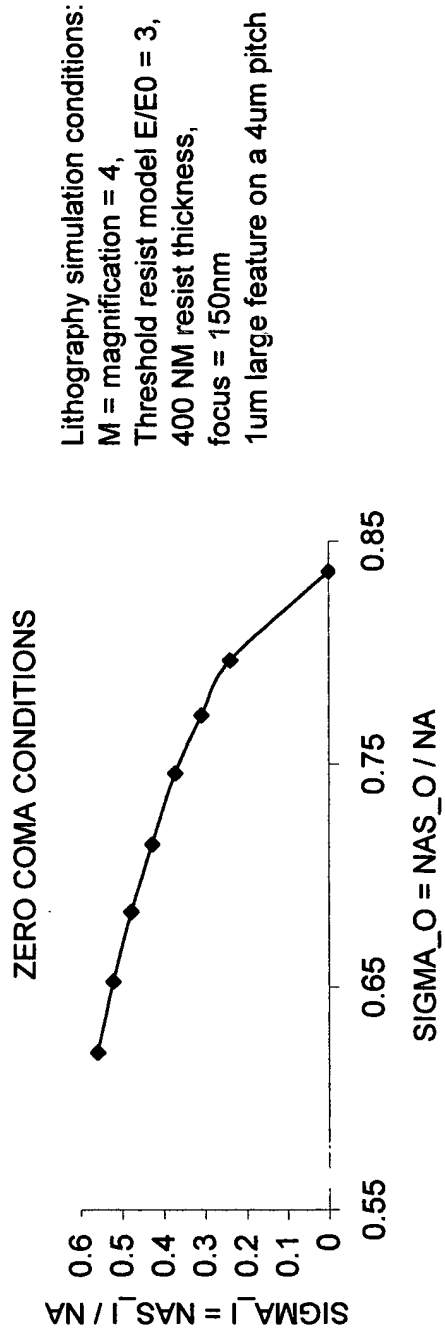

Lithography simulation conditions:
M = magnification = 4,
Threshold resist model E/E0 = 3,
400 NM resist thickness,
focus = 150nm
1um large feature on a 4um pitch
ZERO COMA CONDITIONS
SIGMA_I = NAS_I / NA
0.6
0.5
0.4
0.3
0.2
0.1
0
0.55
0.65
0.75
0.85
SIGMA_O = NAS_O / NA

Figure 8b

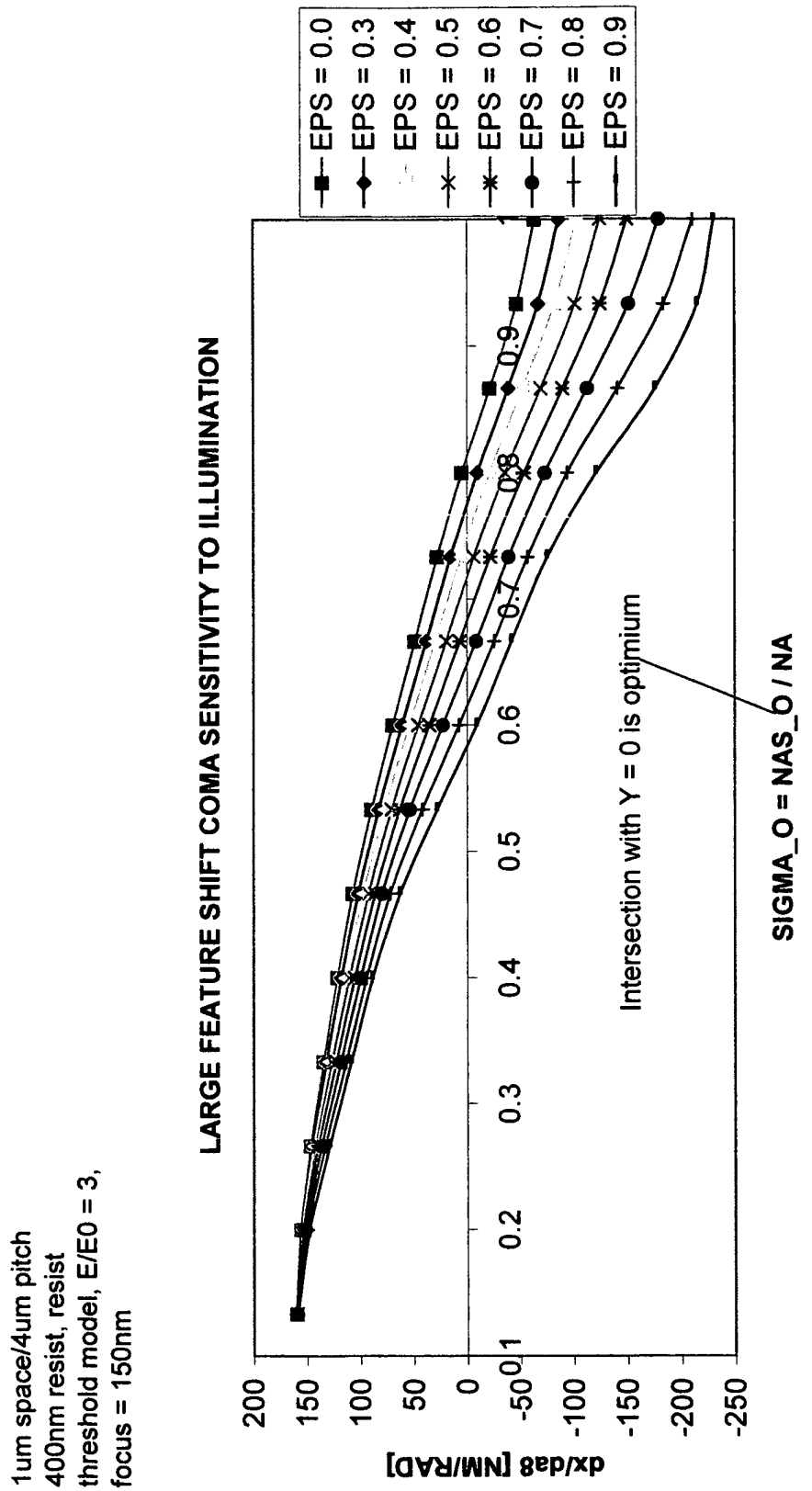

LARGE FEATURE SHIFT COMA SENSITIVITY TO ILLUMINATION
1um space/4um pitch
400nm resist, resist
threshold model, E/E0 = 3,
focus = 150nm
dx/da8 [NM/RAD]
200
150
100
50
0
-50
-100
-150
-200
-250
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
EPS = 0.0
EPS = 0.3
EPS = 0.4
EPS = 0.5
EPS = 0.6
EPS = 0.7
EPS = 0.8
EPS = 0.9
Intersection with Y = 0 is optimium
SIGMA_O = NAS_O / NA

Figure 9a

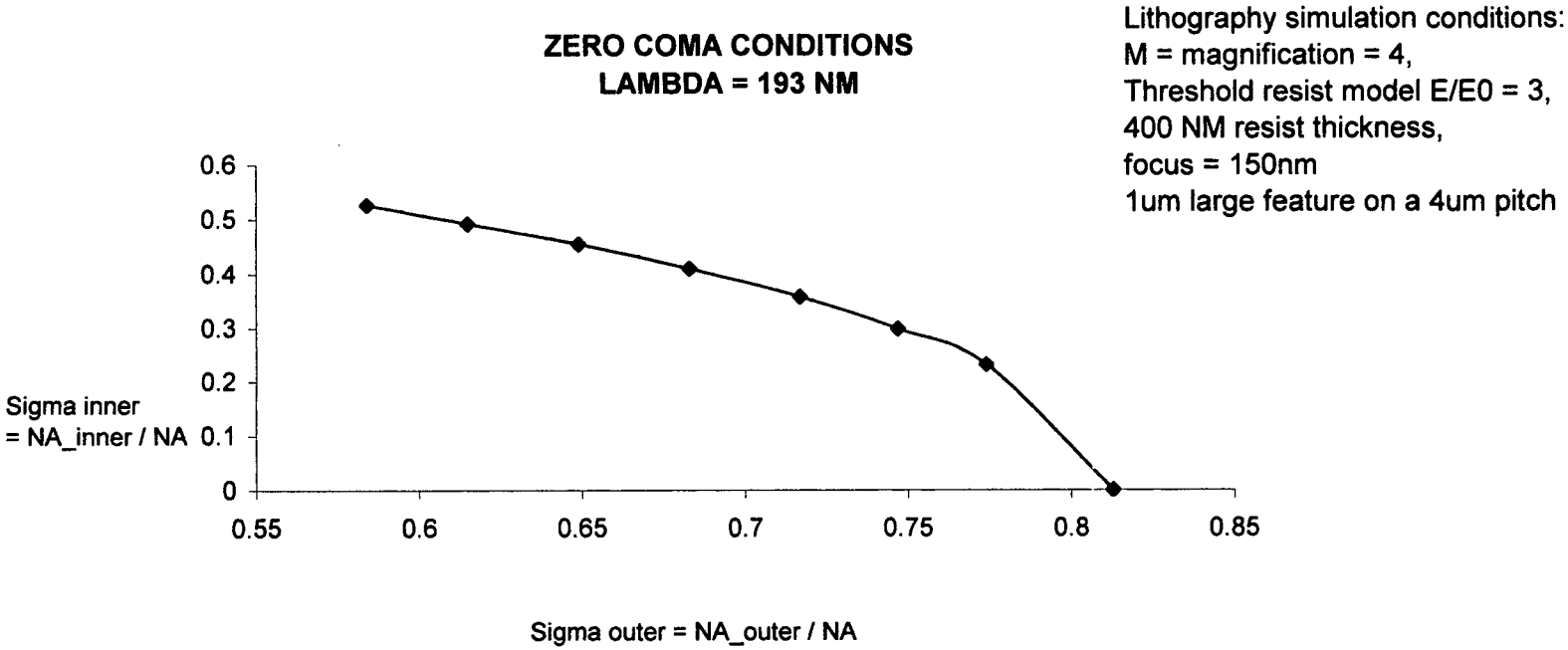


Figure 9b

Heller Ehrman White & McAuliffe LLP
Title: "PROCESS FOR DETERMINATION OF OPTIMIZED EXPOSURE CONDITIONS FOR TRANSVERSE DISTORTION MAPPING"
Inventor(s): A. Smith et al.
Application No.: 10/800,110 – Filed: 03/12/2004
Atty Docket No.: 38203-6295
15/23

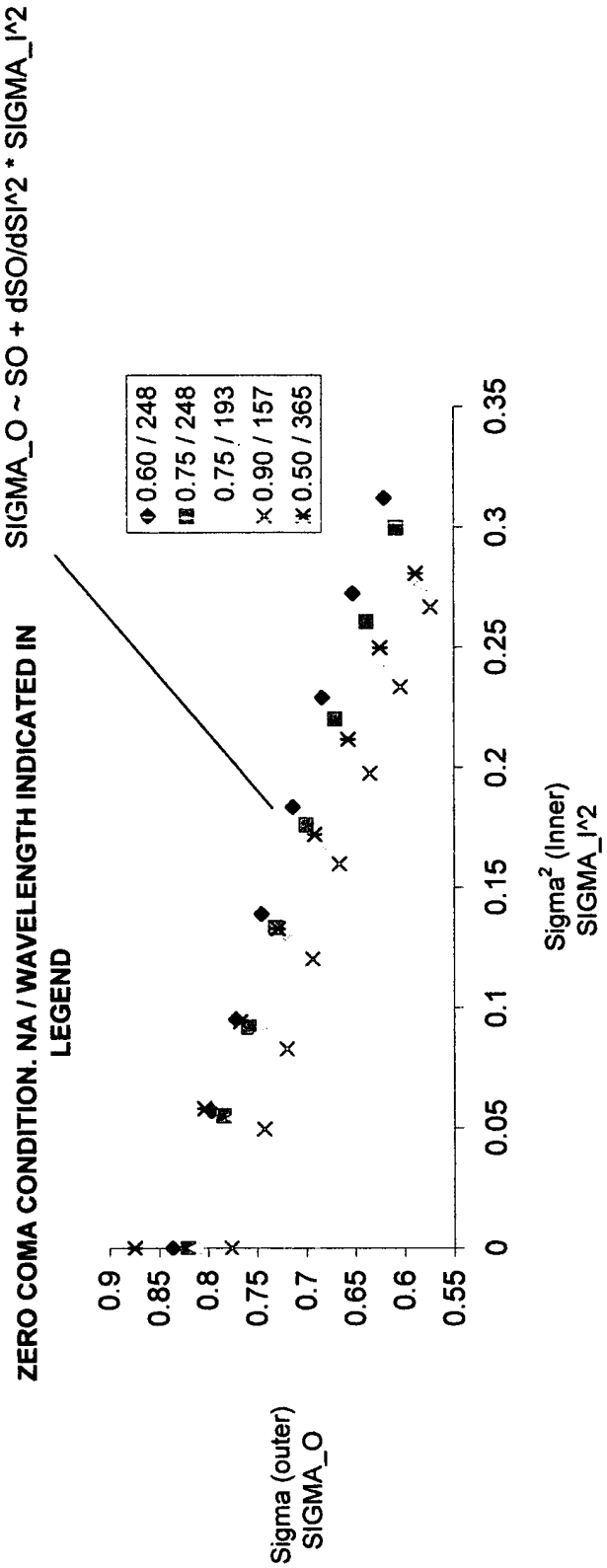

SIGMA_O ~ SO + dSO/dSI^2 * SIGMA_I^2
ZERO COMA CONDITION. NA / WAVELENGTH INDICATED IN LEGEND
0.60 / 248
0.75 / 248
0.75 / 193
0.90 / 157
0.50 / 365
Sigma (outer) SIGMA_O
Sigma² (Inner) SIGMA_I^2
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35

Figure 10a

Figure 10b

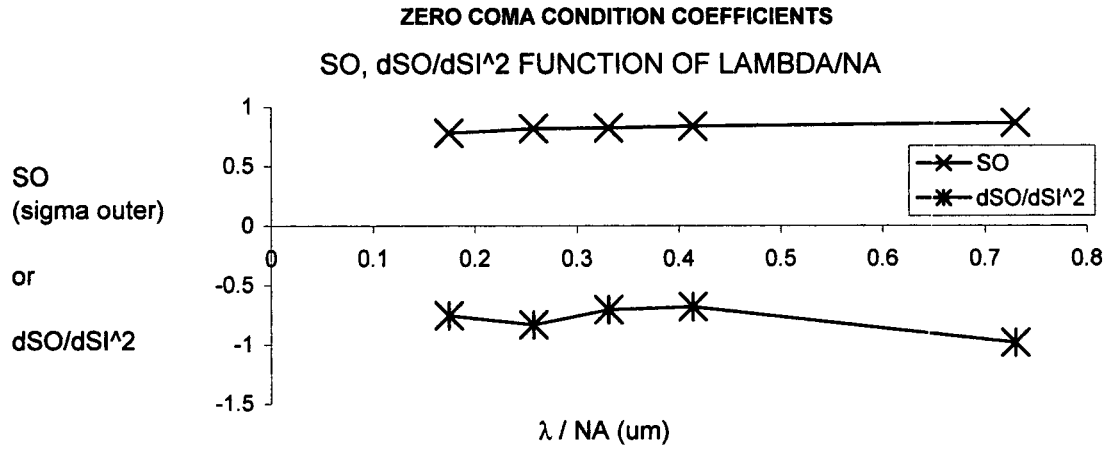


Figure 10c

FITTING COEFFICIENTS AS FUNCTION OF LAMBDA/NA					
LAMBDA/NA [UM]	LAMBDA	NA	SO	dSO/dSI^2	RSQ
0.73	365	0.5	0.8652	-0.9867	0.9969
0.413966667	248.38	0.6	0.8375	-0.6808	0.9989
0.331173333	248.38	0.75	0.8233	-0.706	0.9992
0.257333333	193	0.75	0.819	-0.833	0.9974
0.174444444	157	0.9	0.7813	-0.7539	0.9966

Heller Ehrman White & McAuliffe LLP
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Atty Docket No.: 38203-6295
17/23

Figure 11b

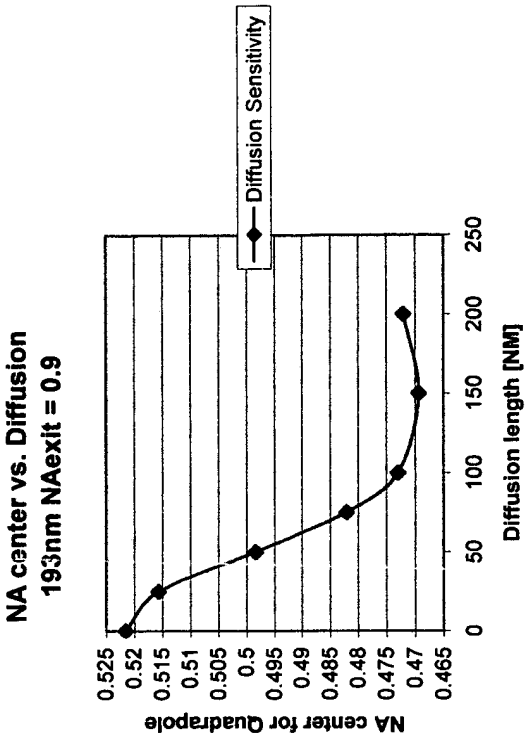
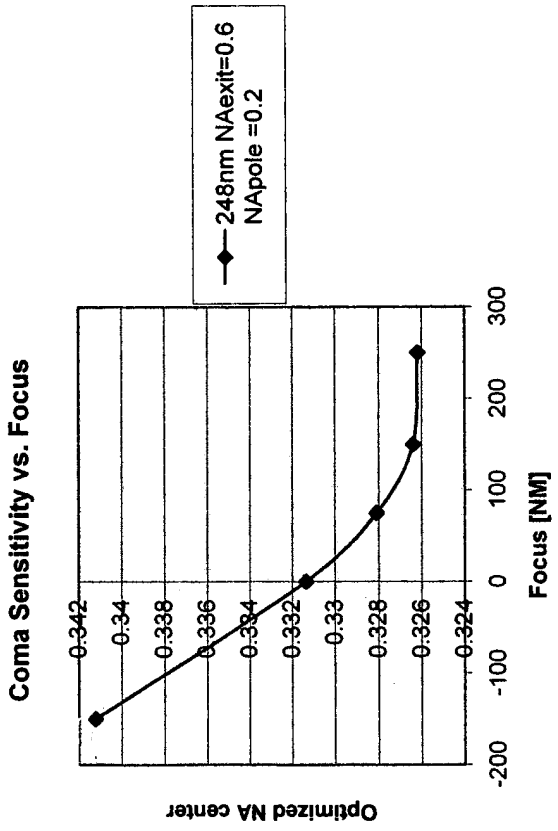


Figure 11a



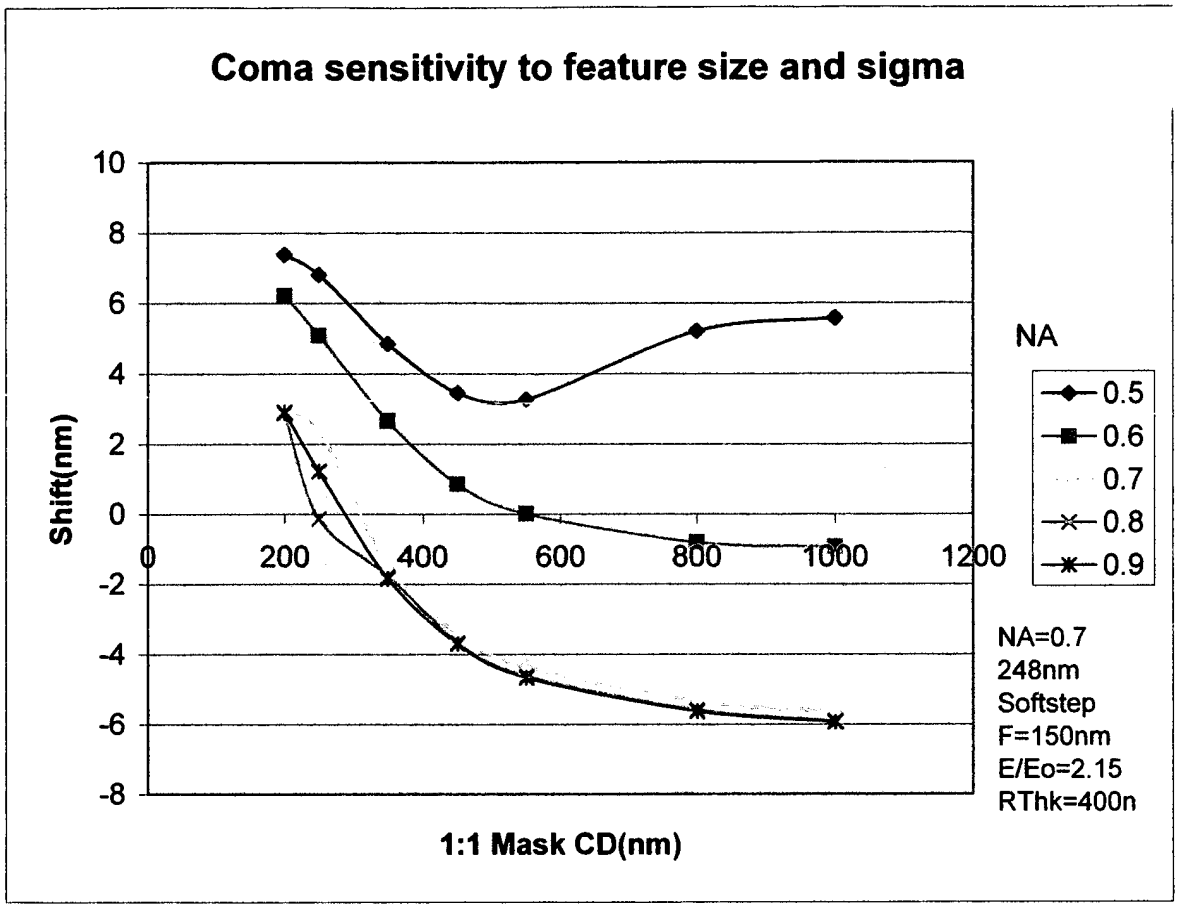

Coma sensitivity to feature size and sigma
Shift(nm)
10
8
6
4
2
0
-2
-4
-6
-8
0
200
400
600
800
1000
1200
1:1 Mask CD(nm)
NA
0.5
0.6
0.7
0.8
0.9
NA=0.7
248nm
Softstep
F=150nm
E/Eo=2.15
RThk=400n

Figure 12

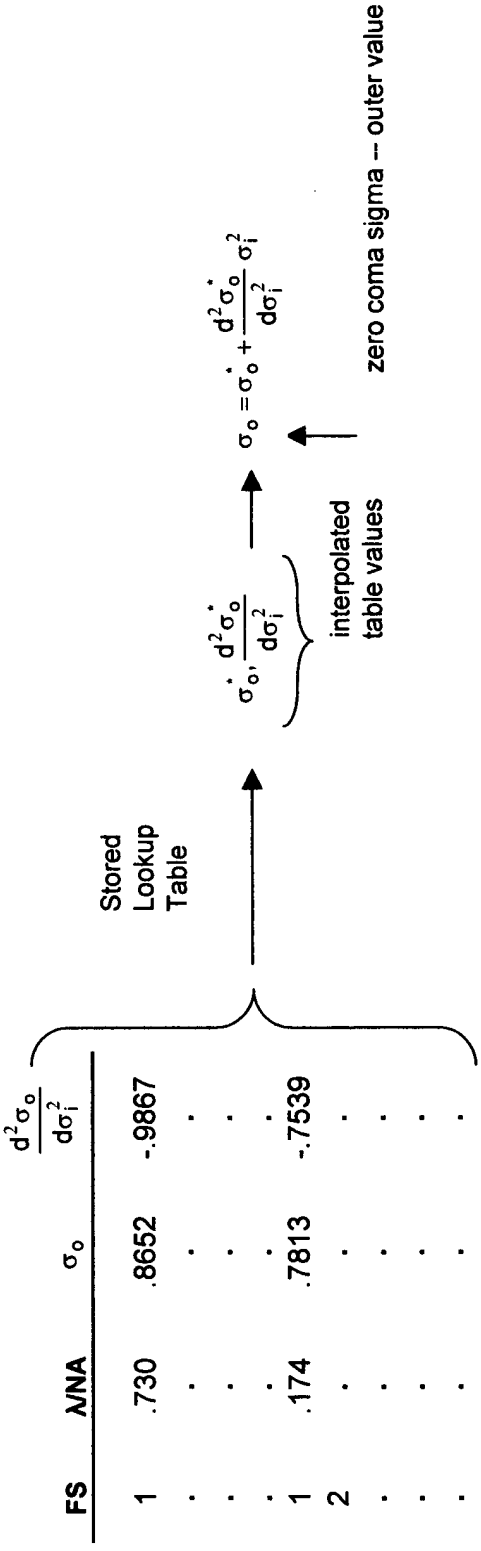

FS
N/NA
σ_o
$\frac{d^2\sigma_o}{d\sigma_i^2}$
1
.730
.8652
-.9867
1
.174
.7813
-.7539
2
Stored Lookup Table
$\sigma_o', \frac{d^2\sigma_o'}{d\sigma_i^2}$
interpolated table values
$\sigma_o = \sigma_o' + \frac{d^2\sigma_o'}{d\sigma_i^2}\sigma_i^2$
zero coma sigma -- outer value

Figure 13

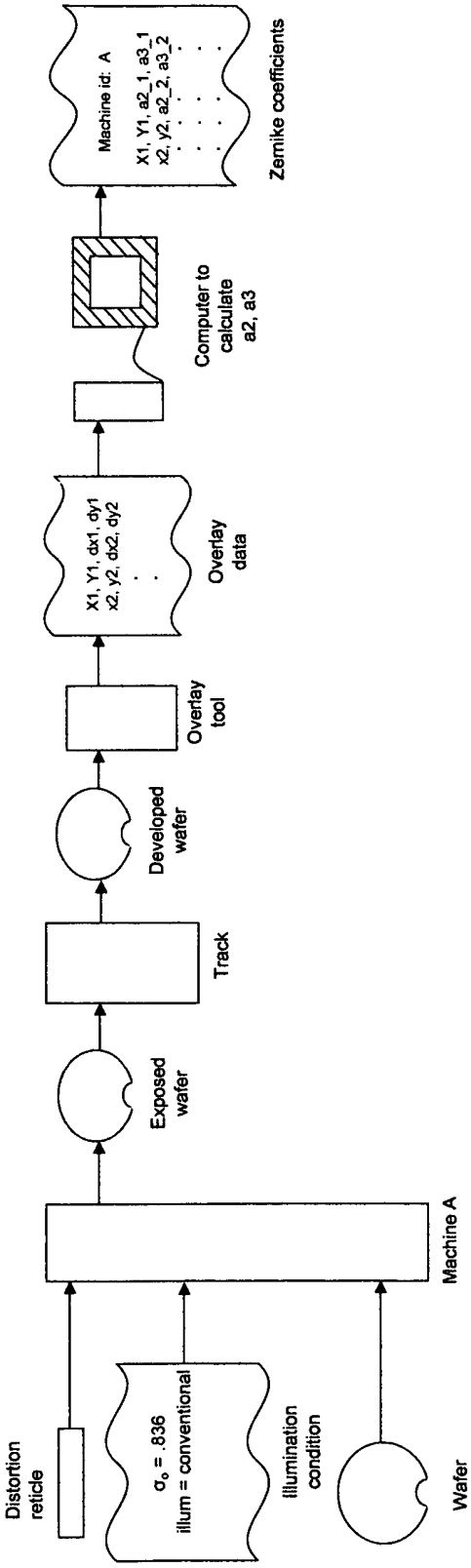

Distortion reticle
σo = .836
illum = conventional
illumination condition
Wafer
Machine A
Exposed wafer
Track
Developed wafer
Overlay tool
X1, Y1, dx1, dy1
x2, y2, dx2, dy2
Overlay data
Computer to calculate a2, a3
Machine id: A
X1, Y1, a2_1, a3_1
x2, y2, a2_2, a3_2
Zernike coefficients

Figure 14

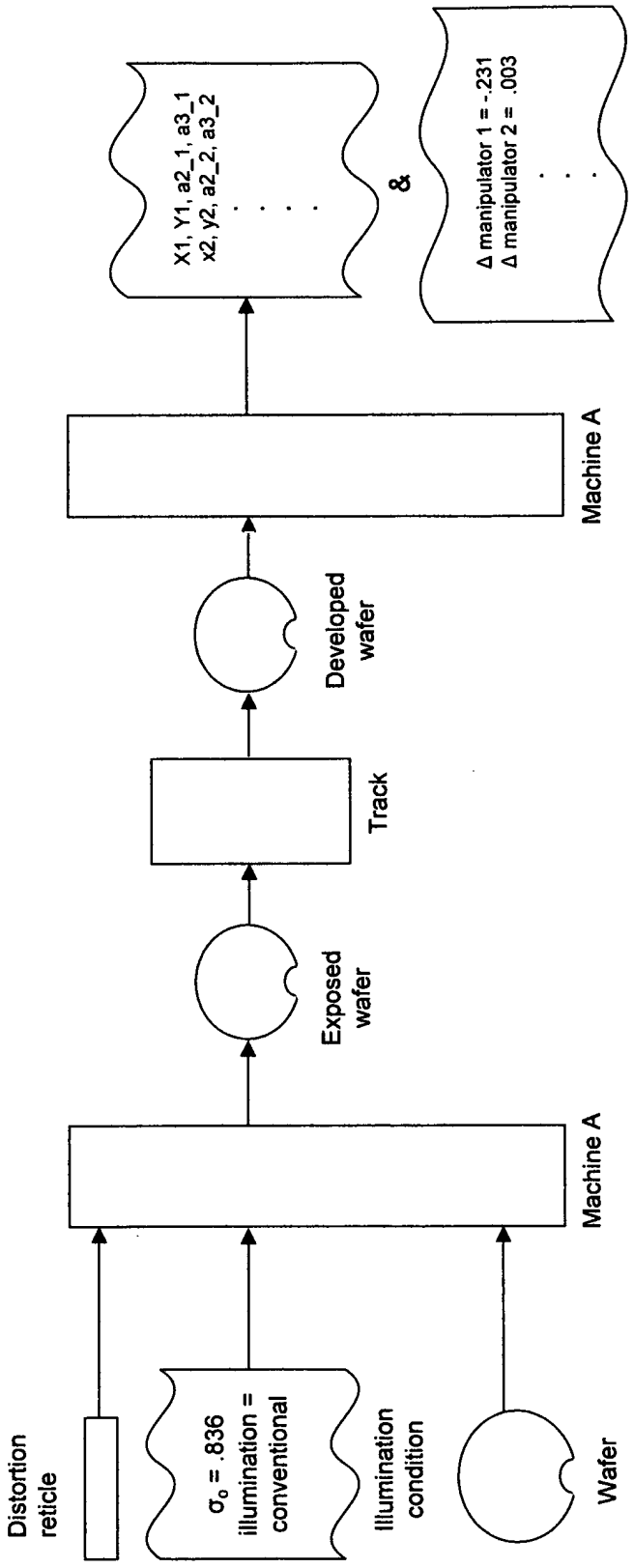

Distortion reticle
σo = .836 illumination = conventional
Illumination condition
Wafer
Machine A
Exposed wafer
Track
Developed wafer
Machine A
X1, Y1, a2_1, a2_2, a3_1
x2, y2, a2_2, a2_2, a3_2
. . . . .
&
Δ manipulator 1 = -.231
Δ manipulator 2 = .003
. . .

Figure 15

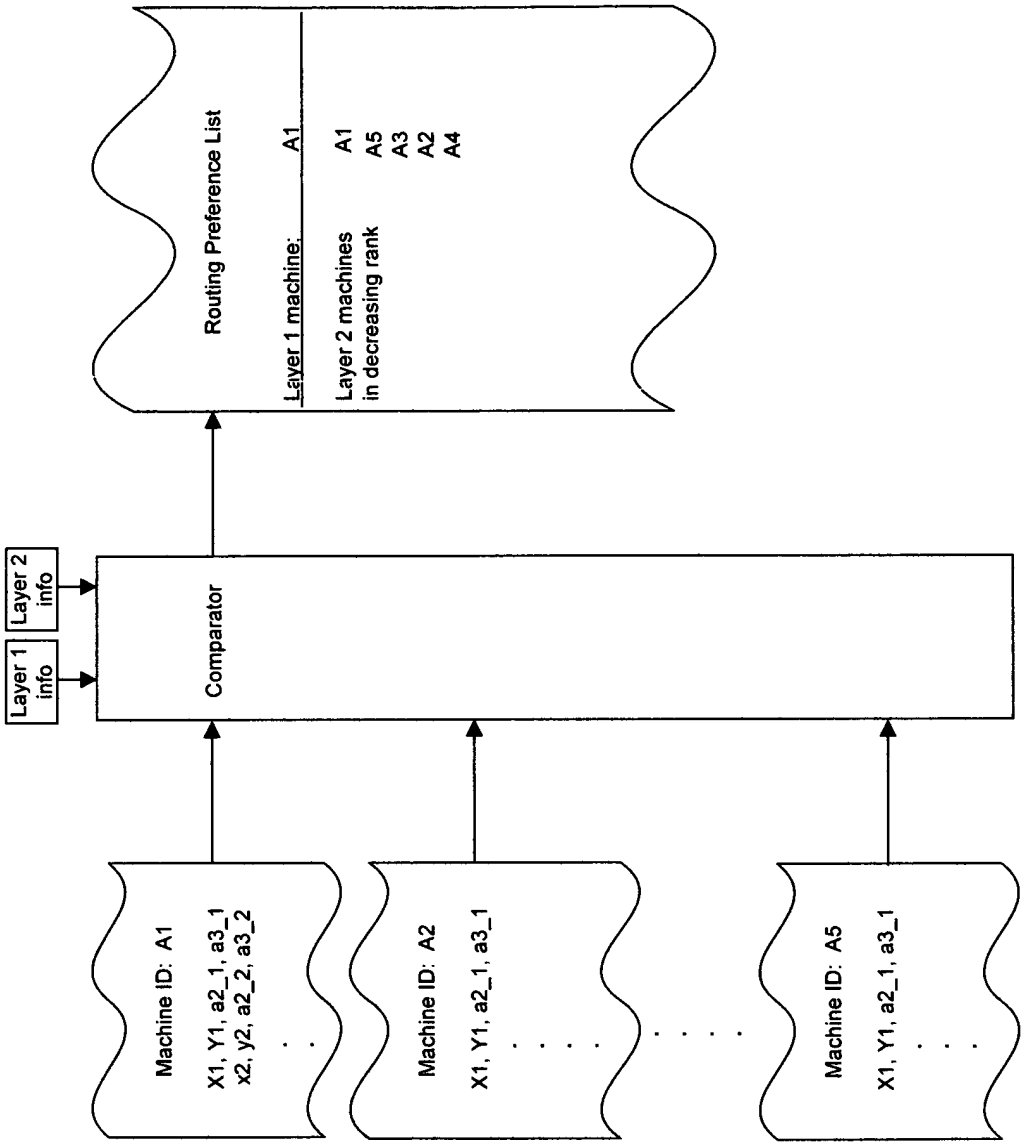

Routing Preference List
Layer 1 machine: A1
Layer 2 machines in decreasing rank
A1
A5
A3
A2
A4
Layer 2 info
Layer 1 info
Comparator
Machine ID: A1
X1, Y1, a2_1, a3_1
x2, y2, a2_2, a3_2
Machine ID: A2
X1, Y1, a2_1, a3_1
Machine ID: A5
X1, Y1, a2_1, a3_1

Figure 16